Electrical Load Management at the Goldstone DSN Complex

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The Southern California Edison Company issued a new time-of-day rate schedule for the Goldstone Complex which substantially increased the cost of commercial power during the daily high usage periods. Subsequently, a Power Load Management Plan was developed which would utilize the unique power generating capabilities of the stations to reduce the stress on the Edison Company's reserve capacity and reduce the cost of electrical power at the stations. The plan, which has now been implemented, has greatly reduced the cost of Goldstone electrical power by completely eliminating the use of commercial power during the Edison Company's high usage periods each day.

I. Introduction

In April 1979 the Southern California Edison (SCE) Company issued a new industrial rate schedule. Upon review of the new schedule it was apparent that the cost of purchased electrical power would sharply increase. SCE's time-of-day charging was designed to provide a substantial increase in the cost of power during high usage periods of the day. Figure 1 contains a 24-hour load profile which illustrates the new summer weekday rate schedule. Energy usage rates were established for "on", "mid", and "off" peak periods. The SCE rate structure also carried a severe penalty for every kilowatt of demand that occurred during the "On Peak" time period.

SCE's rate schedule referred to as No. TOU-8, General Service-Large, is outlined in Table 1. Key aspects of the new schedule include a $5.05 demand charge per kW for the maximum average kW used over a 15-minute period each month, and an energy charge (to be added to the demand charge) for the kWh used during each time-of-day period, i.e., the average kW load for each period multiplied by the hours of the period. The high "On Peak" charges are related to the amount of generating capacity which the power companies have in reserve. The fact that they are high is an indication that the utility has minimal reserve during the high usage "On Peak" periods.

II. Discussion

As anticipated, the cost of purchased electrical power jumped sharply when the new rate schedule became effective. The Deep Space Network Mission Support Operations Division in accordance with JPL Energy Conservation and Economic Policy initiated a three-phase effort. This effort was directed toward determining by load management whether or not we could alleviate, to some degree, the stress on the utility's minimum "On Peak" reserve capacity. Also, would this reduce the cost of electrical power at the Goldstone Tracking Station?

A. Phase I

This phase involved establishing what steps could be taken to reduce the "On Peak" loads and what benefit would be expected.

The Goldstone Complex has two electrical services which are metered separately:

(1) A 2400-volt service to Deep Space Station 14 (Mars).

(2) A 480-volt service to DSS 11, 12 and 13 (Goldstone).

The one-line power diagram in Fig. 2 indicates the metering for the two services as they enter the Goldstone Facility. DSS 11, 12, and 14 have their own powerhouses with diesel generators and an arrangement of circuit breakers to enable them to be synchronized and paralleled with the utility. This means that before the start of the "On Peak" power period the diesel generators could be started and paralleled with the utility and the station load transferred to the generators. The power equipment was capable of making this transfer without any interruption or disturbance to the electrical system. The DSS 14 station has a special dual bus arrangement that enables the high-power transmitter, an intermittent large load, to be connected to the diesel generators while the utility furnishes the balance of the station load.

Quite obviously, load management techniques should be economically rewarding. The penalty for using power during the "On Peak" periods was very high. The question that remained was, would it be cost-effective to generate all "On Peak" power, i.e., would the cost to generate electrical power over the "On Peak" period exceed the cost for utility power if purchased over the same period?

Parameters utilized in predicting the results that would be achieved if the stations were placed on generators during the "On Peak" period are listed in Table 2.

The following is a summary of the expected costs of generated vs commercial power at DSS 11, 12, and 14:

Diesel generation cost – peak periods per month

Fuel cost "On Peak" periods monthly	$ 9,640.00
Fuel cost "Mid Peak" periods	1,760.00
Maintenance cost	840.00
Total cost	$12,240.00

Commercial power costs – peak periods per month

Peak demand cost	$11,310.00
"On Peak"	6,550.00
"Mid Peak"	1,170.00
Total cost	$19,030.00

Predicted GDSCC savings

Commercial cost	$19,030.00
Diesel generator cost	$12,240.00
Monthly savings	$ 6,790.00

It is noted that additional savings could be expected since the analysis did not take into account the savings to be achieved by generating power required for the high-powered transmitter at DSS 14 during the "On Peak" periods.

B. Phase II

To verify the cost of generating power the "On Peak" power was generated at DSS 14 for one month. Complete records were kept and the fuel consumption of 12 kWh/gal was verified during the March billing period. 78,417 kWh of "On Peak" and 18,606 kWh of "Mid Peak" power were supplied by the generators. The following is a summary of the results obtained:

Projected Commercial "On Peak" demand charge	$5,654.00
Projected commercial "On Peak" energy charge	3,474.00
Projected commercial "Mid Peak" energy charge	799.00
Cost of commercial power	$9,927.00
Fuel cost for generated power	$6,145.00
Maintenance cost	279.00
Total cost	$6,424.00
Monthly savings	$3,503.00

However, if the utility's minimum demand charge of $1,252.00 is deducted, monthly savings for DSS 14 are $2,251.00. The minimum demand charge is 25% of the highest demand charge in the preceding 12 months. This charge would disappear after 12 months of "On Peak" power generation.

The estimated savings did not take into account the increased usages of the diesel generators that would eventually cause more maintenance work. However, maintenance does not increase directly proportionally to the number of hours of operation. In fact, by utilizing the engines we may be increasing their reliability. Certainly as far as the powerhouse operation and maintenance personnel are concerned, their level of competence would leap forward and would keep pace with the new demands. Synchronizing and paralleling with the utility would no longer be done only by a select set of personnel. All the electricians would become competent in doing this previously complicated procedure. In other words, extra practice would increase competence and the technical demands and activity would also give them a psychological boost as an added bonus.

C. Phase III

Having established the fact that power generation during "On Peak" periods was cost-effective, a load management plan was devised which would:

(1) Run generators when the high-power transmitter at DSS 14 is required during the "On Peak" periods, utilizing advanced notice from the station to minimize labor involvement.

(2) Run the generators at DSS 11, 12 and 14 to completely cover the "On Peak" station loads starting 30 minutes ahead and finishing 30 minutes after this critical period.

(3) Add at DSS 11, 12 and 14 automatic generator start and load takeover from the utility (stations on generators) at the push button command of the station operator. This would minimize powerplant operator involvement and also provide rapid changeover to generators in the event of storm warnings.

III. Implementation

These load management procedures were implemented during 1980. In March, DSS 14 started "On Peak" generation and even earlier had utilized generators for the high-power transmitter. In August, DSS 11 and DSS 12 implemented "On Peak" generation. Profiles of "On Peak" station loading without load management provided bases for establishing the annual savings. The savings are accurate since they were developed utilizing month-to-month tabulations of previous utility charges corrected to reflect the actual 1980 time-of-day periods. Table 3 lists the factors which determine the cost of generating power at the stations and compares the cost with the utility demand and energy charges. The savings of $120,000 per annum noted in Table 3 did not include the minimum demand charge for either the Mars feeder or the Goldstone feeder. This minimum demand charge would exist for one full year after the "On Peak" demand was reduced to zero. Therefore, the annual savings would be approximately $15,000 less for the first 12 months of active load management. With the Goldstone feeder, it is not possible to reduce the demand to zero due to the power system configuration at DSS 13. This station's controls are not designed to permit paralleling with the utility. It therefore is not practical to use the diesel generators to supply the "On Peak" power since it would be necessary to interrupt the station power at the start and again at the finish of the "On Peak" demand period.

Results of the Load Management Program in eliminating or reducing the "On Peak" demands are reflected in the December 1980 electricity bill for the Goldstone feeder. This shows an "On Peak" demand of 240 kW (previous high demand was 1459 kW.) The "On Peak" demand kW would have reached at least 1140 kW if we had not been on generators during the "On Peak" period. The load management has consequently reduced this by 900 kW. The December 1980 electricity bill for the Mars feeder shows a zero "On Peak" demand as compared to the previous high demand, which was 992 kW.

Initially various objections were raised:

(1) It would require too much manpower from the technical plant services group.

(2) It would increase the maintenance required on the engines and this would further tax the reduced manpower resources.

(3) Heavy workloads or oversight might delay starting the diesels, and just 15 minutes late would allow the "On Peak" demand to register to its full amount, thus aborting a whole month's activity and undermining the year's savings (to eliminate the minimum demand charge).

These objections were quite real and were systematically resolved. An automatic system was introduced first at DSS 14 and then at DSS 12 and DSS 11. This allowed the shift supervisor to press a button on the control console which started two engines and first paralleled them together and then paralleled them to the utility. Once paralleled, the utility was disconnected automatically and the diesel generators were supplying the station load. Thus, we could be assured that if the electricians were not available (say due to some plant emergency), then the station shift supervisors could put the generators on line automatically.

Further, it was decided that sufficient automatic generator plant safety devices existed so that the generator plant could operate satisfactorily and safely without personnel in attendance.

Maintenance was a problem that could not be resolved before the fact. However, experience from DSS 61/63 and DSS 42/43 had not shown any significant increase with increasing hours of operation, at least not until the engines reached the 50,000 to 60,000 hours running time; however, load management was only adding just over 2000 hours per year, and it would be 20 years before the 50,000-hour mark would be reached.

IV. Summary

Load Management techniques have been implemented at the Goldstone Complex to minimize the stress on SCE reserve capacity and lessen the cost of electrical power at the tracking stations. An average of 120,000 kWh per month is no longer required from the utility during high usage periods. The cost of electrical power at the complex has been reduced by a minimum of $10,000.00 each month. Factors such as changes in the cost of fuel and the Utility's fuel adjustment and energy charges affect the accuracy of projected future savings. JPL will continue to monitor these critical parameters to insure that the results obtained through judicial load management are consistent with the established objectives.

Table 1. Southern California Edison Company schedule no. TOU-8

Rates	Per meter per month
Customer Charge	$1,075.00
Demand Charge (to be added to Customer Charge)	
All kW of "On-Peak" billing demand per kW . . . . . . $	5.05
Plus all kW "Mid-Peak" billing demand, per kW	0.65
Plus all kW of "Off-Peak billing demand per kW	No Charge
Energy Charge (to be added to Demand Charge):	
All "On-Peak" kWh, per kWh	4.34¢*
Plus all "Mid-Peak" kWh, per kWh	4.19¢*
Plus all "Off-Peak" kWh, per kWh	4.04¢*

*Includes 3.81¢ Energy Cost Adjustment as of 3 February 1980

Minimum Charge:

The monthly Demand Charge shall be not less than the charge for 25% of the maximum "On-Peak" demand established during the preceding 11 months.

Daily time periods will be based on Pacific Standard Time and are defined as follows:

"On-Peak:"	12:00 noon to 6:00 p.m. summer weekdays except holidays
	5:00 p.m. to 10:00 p.m. winter weekdays except holidays
"Mid-Peak:"	8:00 a.m. to 12:00 noon and 6:00 p.m. to 10:00 p.m. summer weekdays except holidays
	8:00 a.m. to 5:00 p.m. winter weekdays except holidays
"Off-Peak:"	All other hours.

Table 2. Electrical power cost factors

Average load, kW	1290 kW avg[a]
Peak demand	2240 kW[a]
Peak periods per month, hr	
Summer 6 hr × 21.6 days	129.6 hr
Winter 5 hr × 21.6 days	108 hr
Average/month	118 hr
Edison charges[b]	
On peak demand	$5.05/kW
Energy charges – Adjustment cost per kWh used .	3.81¢/kWh
On peak energy charge ($3.81 + 0.53) = ...	4.34¢/kWh
Mid-peak energy charge ($3.81 + 0.38) = ...	4.19¢/kWh
Off-peak energy charge ($3.81 + 0.23) = ...	4.04¢/kWh
Diesel fuel cost	
Cost per gallon of fuel (Dec. 79)	$0.76
kWh per gallon of fuel (average)	12 kWh
Cost/kWh	6.33¢/kWh
Maintenance cost	
Material cost per diesel	$0.75/hr
Number of diesels on-line	8

[a]Values determined from August, September, and October SCE billings.
[b]Latest rate as of February 3, 1980.

Table 3. Cost of power—Goldstone Complex

	Mars feeder (DSS 14)			
Cost of generating	1,449,000 kWh			
Cost of fuel	$\frac{1449000}{12} \times 0.826$	=		\$ 99,739
Average hours run	3350			
Cost of maintenance	(3350 × 0.75)			2,513
				102,252
Utility demand charge				112,110
Utility energy charge				68,103
				180,213
Less cost of generating power				102,252
				77,961
Savings			77,961	
	Goldstone feeder (DSS 11 and 12)			
Cost of generating	1,162,700 kWh			
Cost of fuel	$\frac{1162700}{12} \times 0.826$	=		80,033
Average hours run	3350			
Cost of maintenance	(3350 × 0.75)	=		2,513
				82,546
Utility demand charge				70,478
Utility energy charge				54,647
				125,125
Less cost of generating power				82,546
				42,579
Savings			42,579	
Total savings			120,540	

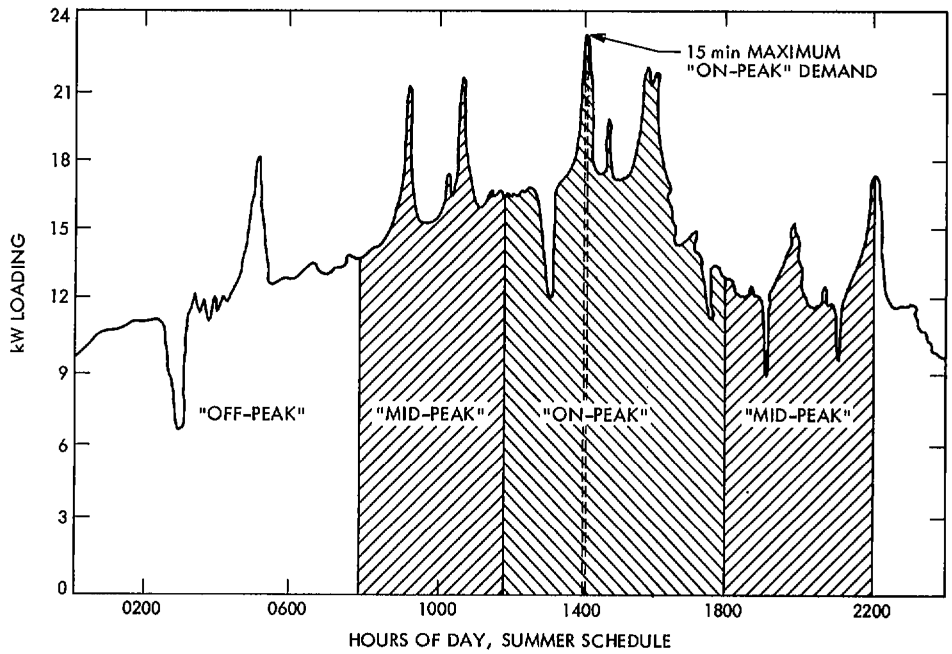

Fig. 1. 24-hour load profile SCE time-of-day schedule

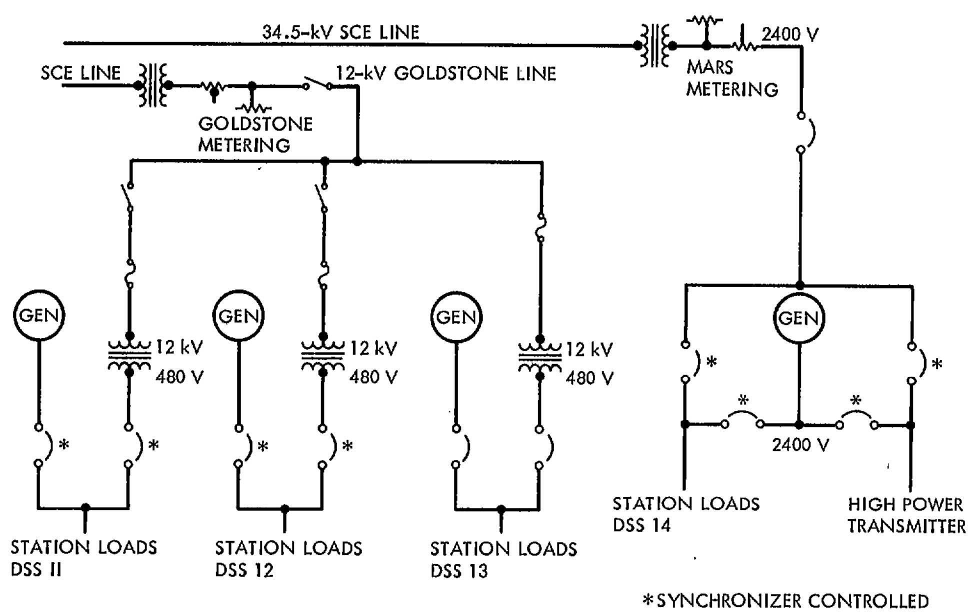

Fig. 2. Simplified power diagram, Goldstone Complex